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TITLE: METHOD AND APPARATUS FOR PROVIDING A DERIVED DIGITAL TELEPHONE VOICE CHANNEL

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# METHOD AND APPARATUS FOR PROVIDING A DERIVED DIGITAL TELEPHONE VOICE CHANNEL

## TECHNICAL FIELD

The present invention relates to telecommunication systems and in particular to a telephone voice and data communication system providing subscriber telephone lines.

## BACKGROUND OF THE INVENTION

Most telephone service subscribers today use familiar analog Plain Old Telephone Service ("POTS") for placing ordinary voice telephone calls. POTS is typically delivered over a subscriber loop of copper wires installed between each subscriber location, such as a home or office, and the local telephone company ("telco") central office. Over the pair of copper wires, voice signals are transmitted between subscribers and the telco central office. The central office then provides circuit-switching equipment to establish connections between subscribers. In such a circuit-switched system, a circuit connection is established for each call and is maintained for the duration of the call.

Recently, on-line computer services, such as

the Internet, have changed the way subscribers use their telephones. On-line computer services typically make a dial-up telephone number available for users with a modem to access the service. Many users of on-line computer services now spend several hours each day on the telephone connected to services such as the Internet. Such a usage pattern ties up the telephone for incoming calls and causes a strain for other members of the household who wish to place calls. In response, households have added a second telephone line for computer data traffic. To provide a second telephone line, a second pair of copper wires is usually provided between the subscriber's location and the telco central office. In addition to more copper wiring, a second telephone line also requires additional central office connection and transmission equipment.

Recently, higher capacity data transmission services have become available to carry a subscriber's computer data to remote computer systems. Such data transmission services often carry data on the same copper pair utilized by POTS. To allow simultaneous data and POTS service and provide greater bandwidth, higher capacity data services operate at frequencies above the 1 KHz to 4 KHz voice frequency band used by POTS. For example, such data services may operate in the frequency range around 80 KHz or higher.

The growing popularity of on-line computer services has also challenged the assumptions upon which the telephone network was constructed. The public switched telephone network (PSTN) is designed with the assumption that only about 10% of residential users and 20% of business users are using the telephone at any given time. The PSTN telephone line and associated circuit-switching equipment are thus designed to be shared by only the fraction of subscribers actually

using the telephone at any time. Now, many households use the telephone for several hours each day to carry data traffic to computer services. Using a POTS circuit-switched telephone call to carry data traffic inefficiently consumes hardware resources, since a dedicated circuit connection is consumed for the entire duration of the call.

More recently, packet-switched data networks have been established to carry high-speed data traffic between distributed computer systems. In addition to providing higher data rates, packet-switched networks are more hardware efficient than circuit-switched networks for carrying data. A packet-switched network establishes a virtual circuit connection which uses transmission resources only when data is actually transmitted. Such a virtual connection is well suited for users of computer services who are connected for long periods of time and spend a relatively small proportion of time actually transmitting and receiving data only occasionally.

Despite the change in communication needs and usage patterns, most data traffic from homes or small offices is carried by POTS voice lines.

## SUMMARY OF THE INVENTION

The present invention allows a telephone subscriber to use a digital data subscriber loop to supply or derive an additional telephone voice line to complement the analog plain old telephone service (POTS) line. Subscribers ordinarily use conventional POTS as their primary voice communication service while the digital subscriber loop carries digital data from devices such as an electronic computer system. The digital subscriber loop also provides an additional telephone line for voice calls.

In a first embodiment of the invention, an analog telephone line and a digital data line share the same subscriber loop. The analog line provides a conventional voice telephone line. The digital data line, in addition to providing digital data service, also provides a digital telephone voice line. The analog telephone line is preferably a conventional POTS telephone line, and the digital data line is preferably a high capacity or an asymmetric digital subscriber. The digital data line preferably implements an asynchronous transfer mode (ATM) transmission protocol.

In another aspect of the invention, an interworking unit (IWU) provides an interface between the digital telephone voice line and a circuit-switching device. The digital voice channel is preferably carried by an ATM transport protocol. In comparison, to enter the public telephone network, the digital voice call must typically be switched by a circuit-switching device using a conventional switching protocol. The IWU converts the ATM transport protocol of the digital telephone voice call to the switching protocol of the circuit-switching device. The digital telephone voice call is then interfaced to the PSTN to be switched as an ordinary telephone call.

With the present invention, subscribers have a both a POTS telephone voice line and a digital data transmission line. A subscriber normally uses the POTS telephone voice line for voice calls and the digital data line for data transmission to on-line computer services. The digital data line is preferably a packet-switched network which uses little transmission resources except when actually transmitting data. In addition, when the POTS telephone line is in use, additional voice telephone calls can be made using a telephone line derived from the digital data line. The derived digital telephone line provides subscribers an

additional voice line.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed. The invention, together with further intended advantages, will best be understood by reference to the following detailed description, taken in conjunction with the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a block diagram of a telephone network system.

Fig. 2 is a diagram of the central office of the telephone network system of Fig. 1.

Fig. 3 is a diagram of the subscriber location of the telephone network system of Fig. 1.

Fig. 4 is a diagram of the tandem location of the telephone network system of Fig. 1.

Fig. 5 is a block diagram of the interworking unit of Fig. 4.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Fig. 1 shows a diagram of a telephone network. Telephone subscribers 10 are typically serviced by analog telephone lines carried to the central office 20 by a subscriber loop 12 including twisted pairs of copper wires. A number of subscribers 14 may also be connected by subscriber loops to a remote terminal 16 which combines a number of subscribers 14 onto a digital multiplexed data line 18 for transmission to the central office 20. For example, a 24 channel multiplexed T1 line is commonly used in North America for the data line 18.

Typically, a number of central offices 20 are connected by direct trunk circuits 22 or through tandem

locations 30. The tandem locations 30 provide trunk circuits 22 to connect two central offices or other tandem locations 30. The tandem locations 30 can thus provide connections between central offices which do not have direct interconnecting trunks. It is to be understood that telephone switching networks may have multiple levels of tandem switching or other network topologies.

Fig. 2 shows a block diagram of the telco central office 20 of Fig. 1. The central office 20 preferably includes a means to provide analog telephone line such as conventional POTS. Conventional POTS is typically handled by the local telephone switching device 23. Local telephone switching devices such as a Northern Telecom DMS-100 or ATT No. 5 ESS are well known to those skilled in the art. In alternative embodiments, an analog telephone line may also be provided by a Centrex type service or private branch exchange (PBX). As known to those skilled in the art, an anlog telephone service may also be provided by a digital carrier system such as a T1 carrier or other type of concentrator.

In addition to POTS service, the central office may also include a means to provide a digital data line. For example, a digital data line may be implemented by a digital subscriber line access multiplexer (DSLAM) 24 to multiplex traffic from digital subscriber loops. Digital subscriber loops or digital carrier systems provided by remote terminal 16 and office terminal 25 provide digital data lines which enable subscribers 10 (Fig. 1) to transmit large amounts of digital multiplexed data traffic over the POTS twisted pair telephone line. The digital subscriber loop is preferably an Asymmetric Digital Subscriber Line (ADSL). ADSL typically implements a digital subscriber line with a maximum data rate from

the central office 20 to the subscriber 10 which is higher than the maximum available data rate from the subscriber 10 to the central office 20. For example, ADSL typically provides an asymmetric data rate of 1.5 megabits-per-second (mbs) to the subscriber from the central office and about 400 kilobits-per-second (kbs) from the subscriber location to the central office. Most preferably, ADSL implements an ATM data transmission protocol between the subscriber 10 (Fig. 1) and the central office 20. Of course, other types of data transmission protocols may be utilized. In alternate embodiments, the digital data line may be provided by other types of digital carrier systems such as a SONET based digital systems.

As shown in Fig. 2, the subscriber loop pairs 12 carrying both analog voice and digital data traffic from subscribers 10 to the central office 20 are terminated at a main distribution frame (MDF) 26. From the MDF 26, the subscriber loops 12 are connected to a means for separating POTS voice 32 frequencies from digital data traffic 34 such as a splitter 28, for example. Preferably, the splitter 28 is implemented by the DSLAM 24. The internal operation of the splitter 28 will be described later in more detail in connection with a splitter at the subscriber 10.

The splitter 28 preferably has two outputs: one for POTS signals and another for data traffic. From the splitter 28, the separated POTS voice signals 32 are connected back to the MDF 26 and onto the local switching device 23 handling POTS telephone calls. The data traffic output of the splitter 28 is directed to the DSLAM 24 to multiplex the digital data into a format suitable for transport on a data network 40. Preferably, the DSLAM 24 multiplexes and packages a number of lower signal rate digital data lines to a SONET OC-3 or a DS-1 rate signal which is carried by a

fiber optic network. Depending on the data network 40, the DLSAM 24 may operate at higher bit rates such as those appropriate for SONET OC-12. It should be understood that the data network 40 may be of many different topologies. Preferably, the data network 40 is connected to a tandem location 30 to allow access to other central offices.

In the case of subscriber loops that are connected to the central office through a digital loop carrier system (i.e., a remote terminal 16 and an office terminal 25), the DSLAM 24 and its splitter 28 are preferably placed at the remote terminal 16. The data and voice signals are separated with the splitter 28, as described above. The voice signals are carried on the digital loop carrier system to the office terminal 25 where they are connected through the MDF 26 to the local circuit switch 23. Preferably, the data signals are carried on a separate optical fiber or SONET frame in the carrier system so that they can easily be separated from the voice signals in the office terminal 25. These signals are transmitted from the office terminal to the data network 40.

Fig. 3 shows a diagram of a telephone subscriber location 10 such as a typical home or small office. A network interface device (NID) 41 connects the subscriber to the public switched telephone network (PSTN). The subscriber loop 12 between the subscriber 10 and the central office 20 is terminated at the NID 41. Customer premise equipment (CPE) 52 such as a standard telephone set or other CPE equipment such as a key system, PBX, or computer network to access the PSTN is connected at the NID 41. Voice signals from an analog telephone line 53 and data signals from a digital data line 55 are typically carried to the subscriber 10 on the same subscriber pair 12.

In the preferred embodiment of the invention, the NID 41 includes a means for separating voice frequency signals from data signals. Preferably, a splitter 44 separates voice frequency signals from the data traffic sharing the subscriber loop 12 wire pair. For example, to separate POTS from data traffic, the splitter 44 typically includes a high-pass filter 46 and a low-pass filter 48. To separate POTS voice signals, the low-pass filter 48 blocks high frequency signals, for example signals above 5 KHz, passing only lower voice frequency signals on a conventional CPE POTS loop 50. The voice signals on the CPE POTS loop 50 are connected to standard telephones 52 such as a Bell 103 set providing conventional POTS service. It should be noted that a conventional computer modem 54 can also utilize the conventional CPE POTS loop 50.

To recover data traffic, the high-pass filter 42 blocks low frequency signals, for example signals below 5 KHz, leaving only high frequency data traffic signals to be sent out on a separate CPE data network loop 56. The CPE data network loop 56 is connected to CPE equipped to access data traffic, for example, a network of personal computers. In the preferred embodiment, the CPE data network 56 implements an asynchronous transfer mode network (ATM). Each of the personal computers 58 is equipped with a ATM network interface card (NIC) to allow the computer to access the CPE data network 56. The NIC 41 preferably also includes data segmentation and reassembly (SAR) capability to packetize data for transmission on the data network 56. Of course, other types of computer networks, such as an Ethernet network, may also be implemented.

Preferably, the CPE data network 56 is also equipped with one or more digital telephones 60 capable of interfacing the data network 56 to allow a

subscriber to place a voice telephone call over the CPE data network 56. For example, a digital telephone 60 may be implemented with one of the personal computers 58 on the data network 56 by adding a telephone handset and an appropriate NIC with telephony functions. The telephone handset transmits and receives analog voice signals similar to a conventional handset. The computer/NIC provides SAR capability for converting analog voice to a digital packet stream for transmission over the CPE data network 56. The data network 56 also carries the basic telephony signalling functions. One such system capable of providing such a digital telephone is an ATM network based telephone system from Sphere Communications in Lake Bluff, Illinois.

Using the CPE data network 56, the subscriber 10 can place a voice call using a telephone line derived from the digital data line. POTS service operates as a usual over the POTS wiring 50 to provide regular telephone service such as a telephone line carrying analog voice signals. In addition, the data network 56 with digital telephone 60 also has the capability to place voice telephone calls using one or more derived voice lines implemented through the data network, as will be explained below in more detail.

Fig. 4 shows a block diagram of a tandem location which contains a tandem voice switch (not shown), a Class 5 local switch 70 and a means for providing access to digital data networks. The Class 5 local switch 70 typically connects local subscriber loops to the telephone network, while a separate tandem voice switch (not shown) provides conventional circuit-switched connections for directing POTS traffic between central offices 20 (Fig. 1) of the PSTN. Class 5 local switches such as the AT&T 5 ESS and the Nortel DMS 100, and tandem voice switches such as the AT&T 4ESS and the

Nortel DMS 250 are known to those skilled in the art. In comparison, the means for providing data access to data networks is preferably a packet switch handling digital data traffic. For example, a data access tandem switch 72 provides access to data networks carrying digital data traffic. Preferably, the data networks are equipped to accept ATM packet-switched connections. The data access tandem switch 72 is an ATM fabric switch configured to provide virtual connections on demand between end users and providers of data networks and services. The data access tandem switch 72 may connect end users to various network service providers (NSPs) such as UUNet, MCI, Sprintnet, and AADS.

The tandem location 30 may also include a means to interface the data access tandem 72 and the Class 5 switch. For example, an interworking unit (IWU) 74 may implement an interface between the data access tandem switch 72 and the Class 5 switch 70 of the PSTN. The IWU 74 enables voice telephone calls carried by the data network 40 to access the PSTN through the Class 5 switch 70. The IWU 74 is capable of converting a voice telephone call in the data network protocol from the data access tandem switch 72 into the circuit-switch protocol of the Class 5 switch 70. Preferably, the IWU 74 interfaces an ATM packet data stream to a multiplexed circuit-switch protocol with dynamic allocation of voice channels such as TR-303.

For example, as seen in Fig. 5, the IWU 74 performs the SAR 76 of voice data from an ATM stream into a analog voice signal. The analog voice signal is then converted 78 into the TR-303 protocol, as known to those skilled in the art. More preferably, as seen in Fig. 6, the IWU 74 converts the packetized ATM voice streams to a digital PCM format which is then converted

to the desired TR-303 protocol. It should be noted that the local switch 70 may also be directly connected to a data access tandem 72 without the IWU interface 74. Newer generation digital switches may be capable of directly interfacing with the data transfer protocol of the data access tandem 72. For example, new generation circuit-switches may directly accept an ATM data stream for switching into the PSTN without the need for an IWU.

With the system of Figs. 1-5, a derived voice telephone line using the data network can be implemented and utilized with the above-described system as follows.

A caller places a digital voice call similar to an ordinary telephone call using the digital telephone 60 of Fig. 3. The SAR function of the digital telephone 60 converts the caller's analog voice signals to a packetized digital data stream for transport over the subscriber data network 56. Preferably, the packetized data stream is in an ATM format.

The subscriber data network 56 carries the derived telephone line data stream to the subscriber loop 12 where it is transported on a digital data line to the central office 20 along with POTS traffic. Note, the derived telephone line uses the digital data line of the subscriber data network 56, leaving the POTS telephone line available for analog telephone voice calls.

At the central office 20 shown in Fig. 2, the splitter 28 separates the derived telephone line data stream from POTS traffic. The derived telephone line data stream is multiplexed by the DSLAM 24 together with a number of data streams or derived telephone line data streams from other subscribers. For example, the DSLAM 24 may combine data streams from a number of

different subscribers into a higher rate digital signal such as a DS-3 or OC-3 signal. The telephone line data stream is then carried by the OC-3 signal over the data network 40 to the tandem location 30.

At the tandem location 30 shown in Fig. 4, the derived telephone line and data sessions are switched by the data access tandem 72. Preferably, data sessions to a NSP are directly switched by the data access tandem 72 to the desired NSP without entering the PSTN. For voice calls which must enter the PSTN, the data access tandem 72 directs the derived telephone line data streams to the IWU 74.

The IWU 74 preferably converts the derived telephone line data stream to a voice signal in a TR-303 format which can be switched by the Class 5 telephone switch 70. Through the Class 5 switch 70, the derived voice call enters the PSTN and is switched as a POTS call. If needed, a separate tandem switch establishes a circuit connection to the desired central office 20.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed. Numerous modifications and variations are possible. It is intended that the foregoing detailed description be regarded as illustrative rather than limiting. It is the following claims, including all equivalents, which are intended to define the scope of this invention.